AMENDMENTS TO THE SPECIFICATION

In the specification, please delete the paragraph at page 18, line 16 through page 22, line 19 and substitute therefor the following substitute paragraph:

-- Referring now to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for the purpose of limiting same, the system used in practicing the invention is shown in detail in FIGURES 1, 2 ~~AND~~and 16. In FIGURE 1 there is a single electric arc welding system S in the form of a single cell to create an alternating current as an arc at weld station WS. This system or cell includes a first master welder A with output leads 10, 12 in series with electrode E and workpiece W in the form of a pipe seam joint or other welding operation. Hall effect current transducer 14 provides a voltage in line 16 proportional to the current of welder A. Less time critical data, such as welding parameters, are generated at a remote central control 18. In a like manner, a slave following welder B includes leads 20, 22 connected in parallel with leads 10, 12 to direct an additional AC current to the weld station WS. Hall effect current transducer 24 creates a voltage in line 26 representing current levels in welder B during the welding operation. Even though a single slave or follower welder B is shown, any number of additional welders can be connected in parallel with master welder A to produce an alternating current across electrode E and workpiece W. The AC current is combined at the weld station instead of prior to a polarity switching network. Each welder includes a controller and inverter based power supply illustrated as a combined master controller and power supply 30 and a slave controller and power supply 32. Controllers 30, 32 receive parameter data and synchronization data from a relatively low level logic network. The parameter information or data is power supply specific whereby each of the power supplies is provided with the desired parameters such as current, voltage and/or wire feed speed. A low level digital network can provide the parameter information; however, the AC current for polarity reversal occurs at the same time. The "same" time indicates a time difference of less than 10 μs and preferably in the general range of 1-5 μs. To accomplish precise

coordination of the AC output from power supply 30 and power supply 32, the switching points and polarity information can not be provided from a general logic network wherein the timing is less precise. The individual AC power supplies are coordinated by high speed, highly accurate DC logic interface referred to as "gateways." As shown in FIGURE 1, power supplies 30, 32 are provided with the necessary operating parameters indicated by the bi-directional leads 42m, 42s, respectively. This non-time sensitive information is provided by a digital network shown in FIGURE 1. Master power supply 30 receives a synchronizing signal as indicated by unidirectional line 40 to time the controllers operation of its AC output current. The polarity of the AC current for power supply 30 is outputted as indicated by line 46. The actual switching command for the AC current of master power supply 30 is outputted on line 44. The switch command tells power supply S, in the form of an inverter, to "kill," which is a drastic reduction of current. In an alternative, this is actually a switch signal to reverse polarity. The "switching points" or command on line 44 preferably is a "kill" and current reversal commands utilizing the "switching points" as set forth in Stava 6,111,216. Thus, timed switching points or commands are outputted from power supply 30 by line 44. These switching points or commands may involve a power supply "kill" followed by a switch ready signal at a low current or merely a current reversal point. The switch "ready" is used when the "kill" concept is implemented because neither inverters are to actually reverse until they are below the set current. This is described in FIGURE 16. The polarity of the switches of controller 30 controls the logic on line 46. Slave power supply 32 receives the switching point or command logic on line 44b and the polarity logic on line 46b. These two logic signals are interconnected between the master power supply and the slave power supply through the highly accurate logic interface shown as gateway 50, the transmitting gateway, and gateway 52, the receiving gateway <u>on lines 44a,46a</u>. These gateways are network interface cards for each of the power supplies so that the logic on lines 44b, 46b are timed closely to the logic on lines 44, 46, respectively. In practice, network interface

cards or gateways 50, 52 control this logic to within 10 μs and preferably within 1-5 μs. A low accuracy network controls the individual power supplies for data from central control 18 through lines 42m, 42s, illustrated as provided by the gateways or interface cards. These lines contain data from remote areas (such as central control 18) which are not time sensitive and do not use the accuracy characteristics of the gateways. The highly accurate data for timing the switch reversal uses interconnecting logic signals through network interface cards 50, 52. The system in FIGURE 1 is a single cell for a single AC arc; however, the invention is directed to tandem electrodes wherein two or more AC arcs are created to fill the large gap found in pipe welding. Thus, the master power supply 30 for the first electrode receives a synchronization signal which determines the timing or phase operation of the system S for a first electrode, i.e. ARC 1. System S is used with other identical systems to generate ARCs 2, 3, and 4 timed by synchronizing outputs 84, 86 and 88. This concept is schematically illustrated in FIGURE 5. The synchronizing or phase setting signals 82-88 are shown in FIGURE 1 with only one of the tandem electrodes. An information network N comprising a central control computer and/or web server 60 provides digital information or data relating to specific power supplies in several systems or cells controlling different electrodes in a tandem operation. Internet ~~information~~ information 62 is directed to a local area network in the form of an ethernet network 70 having local interconnecting lines 70a, 70b, 70c. Similar interconnecting lines are directed to each power supply used in the four cells creating ARCs 1, 2, 3 and 4 of a tandem welding operation. The description of system or cell S applies to each of the arcs at the other electrodes. If AC current is employed, a master power supply is used. In some instances, merely a master power supply is used with a cell specific synchronizing signal. If higher currents are required, the systems or cells include a master and slave power supply combination as described with respect to system S of FIGURE 1. In some instances, a DC arc is used with two or more AC arcs synchronized by generator 80. Often the DC arc is the leading electrode in a tandem electrode

welding operation, followed by two or more synchronized AC arcs. A DC power supply need not be synchronized, nor is there a need for accurate interconnection of the polarity logic and switching points or commands. Some DC powered electrodes may be switched between positive and negative, but not at the frequency of an AC driven electrode. Irrespective of the make-up of the arcs, ethernet or local area network 70 includes the parameter information identified in a coded fashion designated for specific power supplies of the various systems used in the tandem welding operation. This network also employs synchronizing signals for the several cells or systems whereby the systems can be offset in a time relationship. These synchronizing signals are decoded and received by a master power supply as indicated by line 40 in FIGURE 1. In this manner, the AC arcs are offset on a time basis. These synchronizing signals are not required to be as accurate as the switching points through network interface cards or gateways 50, 52. Synchronizing signals on the data network are received by a network interface in the form of a variable pulse generator 80. The generator creates offset synchronizing signals in lines 84, 86 and 88. These synchronizing signals dictate the phase of the individual alternating current cells for separate electrodes in the tandem operation. Synchronizing signals can be generated by interface 80 or actually received by the generator through the network 70. In practice, network 70 merely activates generator 80 to create the delay pattern for the many synchronizing signals. Also, generator 80 can vary the frequency of the individual cells by frequency of the synchronizing pulses if that feature is desired in the tandem welding operation.--

In the specification, please delete the paragraph at page 24, line 6 through page 26, line 13 and substitute therefor the following substitute paragraph:

--The practice of the present invention utilizing the concepts of FIGURES 1 and 2 are illustrated in FIGURES 3 and 4. Workpiece 200 is a seam in a pipe which is welded together by tandem electrodes 202, 204 and 206 powered by individual power supplies PS1, PS2, PS3,

respectively. The power supplies can include more than one power source coordinated in accordance with the technology in Houston 6,472,634. The illustrated embodiment involves a DC arc for lead electrode 202 and an AC arc for each of the tandem electrodes 204, 206. The created waveforms of the tandem electrodes are AC currents and include shapes created by a wave shaper or wave generator in accordance with the previously described waveform technology. As electrodes 202, 204 and 206 are moved along weld path WP a molten metal puddle P is deposited in pipe seam 200 with an open root portion 210 followed by deposits 212, 214 and 216 from electrodes 202, 204 and 206, respectively. As previously described more than two AC driven electrodes as will be described and illustrated by the waveforms of FIGURE 15, can be operated by the invention relating to AC currents of adjacent electrodes. The power supplies, as shown in FIGURE 4, each include an inverter 220 receiving a DC link from rectifier 222. In accordance with Lincoln waveform technology, a chip or internal programmed pulse width modulator stage 224 is driven by an oscillator 226 at a frequency greater than 18 kHz and preferably greater than 20 kHz. As oscillator 226 drives pulse width modulator 224, the output current has a shape dictated by the wave shape outputted from wave shaper 240 as a voltage or digital numbers at line 242. Output leads 217, 218 are in series with electrodes 202, 204 and 206. The shape in real time is compared with the actual arc current in line 232 from Hall Effect transducer 228 by a stage illustrated as comparator 230 so that the outputs on line 234 controls the shape of the AC waveforms. The digital number or voltage on line 234 determines the output signal on line 224a to control inverter 220 so that the waveform of the current at the arc follows the selected profile outputted from wave shaper 240. This is standard Lincoln waveform technology, as previously discussed. Power supply PS1 creates a DC arc at lead electrode 202; therefore, the output from wave shaper 240 of this power supply is a steady state indicating the magnitude of the DC current. The present invention does not relate to the formation of a DC arc. To the contrary, the present invention is the control of the current at two adjacent AC arcs for tandem

electrodes, such as electrodes 204, 206. In accordance with the invention, wave shaper 240 involves an input 250 employed to select the desired shape or profile of the AC waveform. This shape can be shifted in real time by an internal programming schematically represented as shift program 252. Wave shaper 240 has an output which is a priority signal on line 254. In practice, the priority signal is a bit of logic, as shown in FIGURE 7. Logic 1 indicates a negative polarity for the waveform generated by wave shaper 240 and logic 0 indicates a positive polarity. This logic signal or bit controller 220 directed to the power supply is read in accordance with the technology discussed in FIGURE 16. The inverter switches from a positive polarity to a negative polarity, or the reverse, at a specific "READY" time initiated by a change of the logic bit on line 254. In practice, this bit is received from variable pulse generator 80 shown in FIGURE 1 and in FIGURE 5. The welding system shown in FIGURES 3 and 4 is used in practicing the invention wherein the shape of AC arc currents at electrodes 204 and 206 have novel shapes to obtain a beneficial result of the present invention, i.e. a generally quiescent molten metal puddle P and/or synthesized sinusoidal waveforms compatible with transformer waveforms used in arc welding. The electric arc welding system shown in FIGURES 3 and 4 have a program to select the waveform at "SELECT" program 250 for wave shaper 240. In this manner the unique waveforms of the present invention are used by the tandem electrodes. One of the power supplies to create an AC arc is schematically illustrated in FIGURE 5. The power supply or source is controlled by variable pulse generator 80, shown in FIGURE 1. Signal 260 from the generator controls the power supply for the first arc. This signal includes the synchronization of the waveform together with the polarity bit outputted by the wave shaper 240 on line 254. Lines 260a-260n control the desired subsequent tandem AC arcs operated by the welding system of the present invention. The timing of these signals shifts the start of the other waveforms. FIGURE 5 merely shows the relationship of variable pulse generator 80 to control the successive arcs as explained in connection with FIGURE 4.--

In the specification, please delete the paragraph at page 26, line 14 through page 30, line 2 and substitute therefor the following substitute paragraph:

-- In the welding system of Houston 6,472,634, the AC waveforms are created as shown in FIGURE 6 wherein the wave shaper for arc AC1 at electrode 204 creates a signal 270 having positive portions 272 and negative portions 274. The second arc AC2 at electrode 206 is controlled by signal 280 from the wave shaper having positive portions 282 and negative portions 284. These two signals are the same, but are shifted by the signal from generator 80 a distance x, as shown in FIGURE 6. The waveform technology created current pulses or waveforms at one of the arcs are waveforms having positive portions 290 and negative portions 292 shown at the bottom portion of FIGURE 6. A logic bit from the wave shaper determines when the waveform is switched from the positive polarity to the negative polarity and the reverse. In accordance with the disclosure in Stava 6,111,216 (incorporated by reference herein) pulse width modulator 224 is generally shifted to a lower level at point 291a and 291b. Then the current reduces until reaching a fixed level, such as 100 amps. Consequently, the switches change polarity at points 294a and 294b. This produces a vertical line or shape 296a, 296b when current transitioning between positive portion 290 and negative portion 292. This is the system disclosed in the Houston patent where the like waveforms are shifted to avoid magnetic interference. The waveform portions 290, 292 are the same at arc AC1 and at arc AC2. This is different from the present invention which relates to customizing the waveforms at arc AC1 and arc AC2 for purposes of controlling the molten metal puddle and/or synthesizing a sinusoidal wave shape in a manner not heretofore employed. The disclosure of FIGURE 6 is set forth to show the concept of shifting the waveforms, but not the invention which is customizing each of the adjacent waveforms. The same switching procedure to create a vertical transition between polarities is used in the preferred embodiment of the present invention. Converting from the welding system shown in FIGURE 6 to the present invention is generally

shown in FIGURE 7. The logic on line 254 is illustrated as being a logic 1 in portions 300 and a logic 0 in portions 302. The change of the logic or bit numbers signals the time when the system illustrated in FIGURE 16 shifts polarity. This is schematically illustrated in the lower graph of FIGURE 6 at points 294a, 294b. In accordance with the invention, wave shaper 240 for each of the adjacent AC arcs has a first wave shape 310 for one of the polarities and a second wave shape 312 for the other polarity. Each of the waveforms 310, 312 are created by the logic on line 234 taken together with the logic on line 254. Thus, pulses 310, 312 as shown in FIGURE 7, are different pulses for the positive and negative polarity portions. Each of the pulses 310, 312 are created by separate and distinct current pulses 310a, 312a as shown. Switching between polarities is accomplished as illustrated in FIGURE 6 where the waveforms generated by the wave shaper are shown as having the general shape of waveforms 310, 312. Positive polarity controls penetration and negative polarity controls deposition. In accordance with the invention, the positive and negative pulses of a waveform are different and the switching points are controlled so that the AC waveform at one arc is controlled both in the negative polarity and the positive polarity to have a specific shape created by the output of wave shaper 240. The waveforms for the arc adjacent to the arc having the current shown in FIGURE 7 is controlled differently to obtain the advantages of the present invention. This is illustrated best in FIGURE 8. The waveform at arc AC 1 is in the top part of FIGURE 8. It has positive portions 320 shown by current pulses 320a and negative portions 322 formed by pulses 322a. Positive portion 320 has a maximum magnitude a and width or time period b. Negative portion 322 has a maximum magnitude d and a time or period c. These four parameters are adjusted by wave shaper 240. In the illustrated embodiment, arc AC2 has the waveform shown at the bottom of FIGURE 8 where positive portion 330 is formed by current pulses 330a and has a height or magnitude a' and a time length or period b'. Negative portion 332 is formed by pulses 332a and has a maximum ~~amplitude b'~~amplitude d' and a time length c'. These parameters are adjusted by

wave shaper 240. In accordance with the invention, the waveform from the wave shaper on arc AC1 is out of phase with the wave shape for arc AC2. The two waveforms have parameters or dimensions which are adjusted so that (a) penetration and deposition is controlled and (b) there is no long time during which the puddle P is subjected to a specific polarity relationship, be it a like polarity or opposite polarity. This concept in formulating the wave shapes prevents long term polarity relationships as explained by the showings in FIGURES 9 and 10. In FIGURE 9 electrodes 204, 206 have like polarity, determined by the waveforms of the adjacent currents at any given time. At that instance, magnetic flux 350 of electrode 204 and magnetic flux 352 of electrode 206 are in the same direction and cancel each other at center area 354 between the electrodes. This causes the molten metal portions 360, 362 from electrodes 204, 206 in the molten puddle P to move together, as represented by arrows c. This inward movement together or collapse of the molten metal in puddle P between electrodes 204 will ultimately cause an upward gushing action, if not terminated in a very short time, i.e. less than about 20 ms. As shown in FIGURE 10, the opposite movement of the puddle occurs when the electrodes 204, 206 have opposite polarities. Then, magnetic flux 370 and magnetic flux 372 are accumulated and increased in center portion 374 between the electrodes. High forces between the electrodes causes the molten metal portions 364, 366 of puddle P to retract or be forced away from each other. This is indicated by arrows r. Such outward forcing of the molten metal in puddle P causes disruption of the weld bead if it continues for a substantial time which is generally less than 10 ms. As can be seen from FIGURES 9 and 10, it is desirable to limit the time during which the polarity of the waveform at adjacent electrodes is either the same polarity or opposite polarity. As shown in FIGURE 8, like polarity and opposite polarity is retained for a very short time less than the cycle length of the waveforms at arc AC1 and arc AC2. This positive development of preventing long term occurrence of polarity relationships together with the novel concept of pulses having different shapes and different proportions in the positive and negative areas

combine to control the puddle, control penetration and control deposition in a manner not heretofore obtainable in welding with a normal transformer power supplies or normal use of Lincoln waveform technology.--

In the specification, please delete the paragraph at page 31, line 1 through page 32, line 2 and substitute therefor the following substitute paragraph:

-- In FIGURE 12 waveform 380 is used for arc AC1 and ~~waveform 372~~waveform 382 is used for arc AC2. Portions 380a, 380b, 382a, and 382b are sinusoidal synthesized and are illustrated as being of the same general magnitude. By shifting these two waveforms 90°, areas of concurrent polarity are identified as areas 390, 392, 394 and 396. By using the shifted waveforms with sinusoidal profiles, like polarities or opposite polarities do not remain for any length of time. Thus, the molten metal puddle is not agitated and remains quiescent. This advantage of the concept of a difference in energy between the positive and negative polarity portions of a given waveform. FIGURE 12 is illustrative in nature to show the definition of concurrent polarity relationships and the fact that they should remain for only a short period of time. To accomplish this objective, another embodiment of the present invention is illustrated in FIGURE 13 wherein previously defined waveform 380 is combined with waveform 400, shown as the sawtooth waveform of arc AC2 (a) or the pulsating waveform 402 shown as the waveform for arc AC2(b). Combining waveform 380 with the different waveform 400 of a different waveform 402 produces very small areas or times of concurrent polarity relationships 410, 412, 414, etc. In FIGURE 14 the AC waveform generated at one arc drastically different than the AC waveform generated at the other arc. This same concept of drastically different waveforms is illustrated in FIGURE 14 wherein waveform 420 is an AC pulse profile waveform and waveform 430 is a sinusoidal profile waveform having about one-half the period of waveform 420. Waveform 420 includes a small penetration positive portion 420a and a

large deposition portion 420b with straight line polarity transitions 420c. Waveform 430 includes positive portion 430a and negative portion 430b with vertical polarity transitions 430c. By having these two different waveforms, both the synthesized sinusoidal concept is employed for one electrode and there is no long term concurrent polarity relationship. Thus, the molten metal in puddle P remains somewhat quiescent during the welding operation by both arcs AC1, AC2.--

In the specification, please delete the paragraph at page 33, line 11 through page 34, line 19 and substitute therefor the following substitute paragraph:

-- The implementation of the switching for all power supplies for a single AC arc uses the delayed switching technique where actual switching can occur only after all power supplies are below the given low current level. The delay process is accomplished in the software of the digital processor and is illustrated by the schematic layout of FIGURE 16. When the controller of master power supply 500 receives a command signal as represented by line 502, the power supply starts the switching sequence. The master outputs a logic on line 504 to provide the desired polarity for switching of the slaves to correspond with polarity switching of the master. In the commanded switch sequence, the inverter of master power supply 500 is turned off or down so current to electrode E is decreased as read by hall effect transducer 510. The switch command in line 502 causes an immediate "kill" signal as represented by line 512 to the controllers of paralleled slave power supplies 520, 522 providing current to junction 530 as measured by hall effect transducers 532, 534. All power supplies are in the switch sequence with inverters turned off or down. Software comparator circuits 550, 552, 554 compare the decreased current to a given low current referenced by the voltage on line 556. As each power supply decreases below the given value, a signal appears in lines 560, 562, and 564 to the input of a sample and hold circuits 570, 572, and 574, respectively. The circuits are outputted by a strobe signal in line 580 from each of the power supplies. When a set

logic is stored in a circuit 570, 572, and 574, a YES logic appears on lines READY^1, READY^2, and READY^3 at the time of the strobe signal. This signal is generated in the power supplies and has a period of 25 μs; however, other high speed strobes could be used. The signals are directed to controller C of the master power supply, shown in dashed lines in ~~FIGURE 8~~FIGURE 16. A software ANDing function represented by AND ~~gate 580~~gate 584 has a YES logic output on line 582 when all power supplies are ready to switch polarity. This output condition is directed to clock enable terminal ECLK of software flip flop 600 having its D terminal provided with the desired logic of the polarity to be switched as appearing on line 504. An oscillator or timer operated at about 1 MHz clocks flip flop by a signal on line 602 to terminal CK. This transfers the polarity command logic on line 504 to a Q terminal 604 to provide this logic in line 610 to switch slaves 520, 522 at the same time the identical logic on line 612 switches master power supply 500. After switching, the polarity logic on line 504 shifts to the opposite polarity while master power supply awaits the next switch command based upon the switching frequency. Other circuits can be used to effect the delay in the switching sequence; however, the illustration in FIGURE 16 is the present scheme.--

In the specification, please delete the paragraph at page 35, line 14 through page 37, line 6 and substitute therefor the following substitute paragraph:

-- As so far described, the technology used in practicing the present invention is explained in detail. The technology in FIGURES 1-16 is employed in the preferred embodiment of the present invention. The invention involves an electric arc welder schematically illustrated in FIGURES 17 and 18 and involves tandem electric arc welding wherein first electrode E1 and second electrode E2 are connected in modified series. The subsequent electrodes, one of which is illustrated as electrode E3, are driven in unison with electrodes E1 and E2 and perform a tandem welding process. Of course, several trailing electrodes E3 are normally used. Only one trailing electrode E3 is illustrated

and the same disclosure relates to the other anticipated trailing electrodes. The technology described in FIGURES 1-16 is applicable to electric arc welder 700 used to deposit metal in ~~groove702~~groove 702 of ~~workpiece P~~workpiece W. In the illustrated embodiment, the ~~workpiece P~~workpiece W is spaced plates 710, 712 with a small gap b where edges 714, 716 define trough 704 in plate B having an angle 718, best shown in FIGURE 18. Electrodes E1, E2 are arranged, as shown in FIGURE 17, and are directed toward a point in groove 704, best shown in FIGURE 18. This point is below the electrical contact 750 and defines a stickout h. Referring now more specifically to FIGURE 17, mechanism 720 drives lead electrodes E1, E2 along groove 702 and includes a main power source 722, with output terminals 724, 726 to direct AC current by way of leads 730, 732 to the respective electrodes E1, E2. The electrodes are supplied from spool 740, 742, respectively, and are driven through contacts 750, 752 by standard wire feeders 760, 762, respectively. Wire feeder 760 includes drive rolls 760a, 760b rotated by a motor 760c. In a like manner, wire feeder 762 includes drive rolls 762a, 762b rotated by motor 762c. Leads 760d and 762d are both powered by a control signal in line 764 from main power source 722. The power source is a Power Wave unit sold by The Lincoln Electric Company of Cleveland, Ohio and is generally disclosed in Blankenship 5,278,390. Power source 722 is used to control both wire feeders 760, 762. This results in a limitation, since a single signal is available from the power source to drive the wire feeder. When this occurs, the signal on ~~line 174~~line 764 must be a compromise signal between the desired wire feed speed of electrodes E1, E2. In practice, the single signal on line 764 drives both wire feeders. Of course, software could be developed for providing separate controls for the individual wire feeders at a substantial cost. Separate signals for the wire feeder are created when using two power sources, as shown in FIGURES 20 and 21. Lead 732 is connected to contact 752 by line 734 and to ~~workpiece P~~workpiece W by line 736. Thus, current flow between electrode E1 and power source 722 is through a low resistance line 734 and a higher resistance line 736. The

resistance of these return ~~parths~~paths divides the current flow to adjust the heat in the arc and penetration by the arc force in the welding process. By using the mechanism 720, high deposition by using two series electrodes is accomplished at low heat. A limited amount of current flows from electrode E1 into the workpiece during the welding operation. This welding process is controllable in accordance with the present invention, by the circuit schematically illustrated in FIGURE 19.--

In the specification, please delete the paragraph at page 37, line 7 through page 37, line 17 and substitute therefor the following substitute paragraph:

-- In accordance with the preferred embodiment of the invention, electrodes E1, E2 are trailed by at least one electrode E3, shown in FIGURE 17. This trailing electrode is driven by mechanism 770 in unison with electrodes E1, E2 even though they may be moved by different mechanisms. In the preferred embodiment, the same moving device is used for mechanisms ~~700~~720, 770. The trailing electrode mechanism includes auxiliary power source 772 which is also a Power Wave unit manufactured by The Lincoln Electric Company of Cleveland, Ohio. This power source has output terminals 774, 776 for directing an AC current waveform by way of lines 780, 782 to use electrode E3 in a welding process. Electrode E3 is supplied by spool 784 and is driven through contact 786 by wire feeder 790, similar to wire feeders 760, 762. Wire feeder 790 has spaced drive rolls 790a, 790b rotated by a motor 790. A control signal from power source 772 in line 792 drives motor 790c to feed electrode E3 toward ~~workpiece P~~workpiece W at a speed determined by the signal in line 792.--

In the specification, please delete the paragraph at page 37, line 18 through page 38, line 17 and substitute therefor the following substitute paragraph:

-- In operation of the preferred embodiment illustrated in FIGURES 17 and 18, electrodes E1, E2 and trailing electrode E3 create a weld puddle 800 in groove 702. Electrodes E1, E2 create a first

root pass 802, which bead joins or tacks edges 714, 716 together by melting the inwardly ~~rejecting a portion~~projecting portions of groove 702. Thereafter, puddle 800 is enlarged by overlaying bead 804 by trailing electrode E3. In practice, further electrodes are used to fill groove 702 in a tandem welding process disclosed in FIGURES 1-16. In practice, electrode E3 is used in a submerged arc welding process utilizing a flux dispenser 810 in front of electrode E3 and having a dispensing motor 812 for dispensing flux F from hopper 814 through tube 816 in accordance with standard submerged welding technology. Of course, electrode E1, E2 also are used in a submerged arc AC welding process. A similar flux dispenser 810 is then provided above groove 702 in front of electrode E1. In practice, a shielding gas has also been employed around electrodes E1, E2. The present invention utilizes a power wave power source for the main power source 722 and for the auxiliary power source 772. These power sources are digitally controlled and utilize a waveform technology pioneered by The Lincoln Electric Company whereby the power sources create waveforms that comprise a series of individual current pulses created at a high switching speed in excess of 18 kHz and preferably substantially greater than 20 kHz. In practice, the waveforms are provided by a series of current pulses created at a rate of over 40 kHz. In this manner, the AC current of mechanism 720 and mechanism 770 are provided with any AC waveform to optimize the welding process for the lead electrodes as well as the trailing electrodes. This type of welding process is schematically illustrated in FIGURE 19, which represents the power source used in practicing the preferred embodiment of the present invention.--

In the specification, please delete the paragraph at page 38, line 18 through page 40, line 9 and substitute therefor the following substitute paragraph:

-- System 900 of the present invention is schematically illustrated in FIGURE 19 wherein a Power Wave power source 910 has a high switching output stage 912 with an input rectifier 914 for

receiving three phase line current L1, L2, and L3, and output terminals 912a and 912b. Output stage 912 creates an AC waveform at output terminals 912a, 9112b to perform an AC arc welding process at weld station WP illustrated as including electrode 920 and workpiece 922 and having a current shunt 930 to output a signal in line 932. This signal represents the current of the welding process being performed at weld station WP. Comparator 940 receives the signal on line 932 and has an output 940a with a voltage controlling pulse width modulator circuit 942, which can be digital or analog and has a variety of configurations. The pulse width modulator is driven at high speed by oscillator 944 which, in practice, operates at a frequency of about 40 kHz. This frequency of the oscillator driving the pulse width modulator and provides a series of current pulses at a high speed switching rate to create an AC waveform at station WP. The polarity of the waveform is controlled by the logic or signal from network 950 having an input line 952 from waveform generator 960 and an output line 954 for controlling the polarity of the waveform outputted from stage 912 of the Power Wave power source unit. The profile of the waveform comprising a series of rapidly created pulses is controlled and dictated by waveform generator 960 having a select network 962 which selects the desired waveform to be created at output terminals 912a, 912b of stage 912. By the selected waveform from network 962, the desired waveform is created for use by the electric arc welding mechanisms 720 and 770. In accordance with the invention, the waveform between electrodes E1, E2 is adjusted as shown in system 900. The waveform of the trailing electrode, illustrated as electrode E3, is controlled by the circuits illustrated and discussed with respect to FIGURES 1-16. To control the waveform used for the series connected electrodes E1, E2, system 900 includes waveform adjusting circuits 972-978, each having adjusting networks 972a-978a. Circuit 972 adjusts the frequency of the waveform. After the waveform is selected by network 962, a signal from circuit 972 adjusts the frequency of the AC waveform. In a like manner, the duty cycle of the waveform is controlled by circuit 974. Duty cycle is the relative time the waveform is in the

positive polarity compared to the time in the negative polarity. Circuits 976 and 978 control the magnitude of the current during the negative portion of the waveform or the positive portion of the waveform. Circuit 976 is to adjust the magnitude of the negative portion of the waveform. Circuit 978 adjusts the magnitude of the positive portion of the waveform. The waveform used for electrodes E1, E2 is an AC wave form. However, a DC waveform could be used for a trailing electrode E3, although AC current is preferred. Indeed, it is preferred to use an AC waveform for all electrodes of electric arc welder 700. Other circuits have been used to adjust the signal on line 970 to modulate and change the profile of the wave shape selected by network 962 to optimize welding at the intersection of electrodes E1, E2.--

In the specification, please delete the paragraph at page 40, line 10 through page 42, line 6 and substitute therefor the following substitute paragraph:

-- To increase the amount of current available for the welder shown in FIGURE 17 using the system shown in FIGURE 19, a modified electric arc welder 980 is shown in FIGURE 20. Only the leading series connected electrodes E1, E2 are illustrated; however, trailing electrodes E3 would be employed in welder 980. The welder is used to obtain more welding current by forming main power source 722 into a modified power source 722a including two separate Power Wave units 982, 984. These units are connected in parallel to double the current capacity. Output leads 982a, 982b are connected to terminals 724, 726, respectively. Output leads 984a, 984b are also connected to terminals 724, 726, respectively. Thus, welder 980 operates as welder 700 shown in FIGURES 17 and 18 by using system 900 shown in FIGURE 19. By using parallel power sources, the available current is increased, without increasing the capacity of the individual power source. Furthermore, modules 982, 984 generate their own wire feeder control signals in lines 982c, 984c, respectively. Thus, wire feeders 760, 762 are controlled by separately adjustable signals available in each of the

two power sources 982 and 984. Thus, the individual wire feed speed of electrodes E1, E2 are adjusted using welder 980. A similar modification of the preferred embodiment illustrated in FIGURES 17-19 is schematically illustrated in FIGURE 21 which shows tandem electrode welder 990 including a main power source 992 and a second power source 994. The main power source 992 has output terminals 996a and 996b. These terminals are connected to leads 992a and 992b, respectively. Lead 992a connects the one output of power source 992 to contact 750 of electrode E1. Line 992b is connected to line 1000 for current flow in a path to and from contact E2. To connect terminal 996b in the path of the workpiece ground, second power source 994 is connected in series between terminal 996b and ~~workpiece P~~workpiece W. Power source 994 has terminals 998a, 998b. In this manner, second power source 994 is in series with the lead 994b connected to terminal 998b. In this architecture, electrode E1 carries full current and the current to and from electrode E1 is divided between electrode E2 and lead 994b. This is like the architecture of FIGURE 16. However, lead 994a from terminal 998a is connected to lead 992b from power source 992. Consequently, the two power sources 992 and 994 are connected in series between the ground 994b and lead 992a. Between the two power sources, lead 1000 is connected to contact 752 of electrode E2. Consequently, electrodes E1 and E2 are in series with a ground current path through Power Wave power source 994. By using this arrangement, the waveforms used for both power source 992 and 994 are the same and are each created by a system 900 as shown in FIGURE 19. Adjustments are made to the waveform process by power source 994 to control the current flowing in the ground path of the welder shown in FIGURE 21. Since two separate power sources are employed, wire feeder 760 is controlled by the signal on line 992c from power source 992. A second wire feeder signal in line 994c is controlled by power source 994. As discussed with respect to the welder shown in FIGURE 20, welder 990 has the advantage of being able to control wire feeders 760, 762 separately without complex software in the power source digital control section. In essence, FIGURE 20 shows

a main power source with two parallel modules. In FIGURE 21 series connected modules are used; however, the second module is connected in series with the ground line to better control the current waveform in the ground return circuit or path.--